Report to Biosecurity New Zealand on valuing the freshwater environment

Assessing the marginal dollar value losses to a freshwater lake ecosystem from a hypothetical aggressive weed incursion

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1 Executive summary

This paper reports on a choice experiment to estimate Willingness To Pay (WTP) and Compensating Surplus (CS) for environmental attributes of a freshwater lake. It forms part of a larger study for Biosecurity New Zealand (BNZ) aimed at developing a decision support system for invasive species impacting on indigenous biodiversity.

The aim of the freshwater case study is to elicit dollar values of impacts on indigenous biodiversity due to a hypothetical incursion of an exotic weed from four population samples at varying distances from the incursion. The hypothetical question is the willingness to pay for maintaining or limiting deterioration of key environmental aspects of Lake Rotoroa (Hamilton Lake) due to the weed hydrilla with the focus on impacts on indigenous biodiversity. The payment vehicle for eliciting willingness to pay is a special tax on rate payers assessed annually for five years. Choice modelling (CM) is the stated preference tool used to elicit marginal dollar values for the key attributes of the lake.

Hydrilla was chosen as the case study invasive as it is BNZ's top priority weed. Although restricted to only three lakes in Hawkes Bay area it has the greatest potential for negative impacts on New Zealand's freshwater systems. Hydrilla is a submerged freshwater perennial plant that is characterised by prolific growth and tolerance of a wide range of freshwater habitats from clear, murky, still or flowing water; temperature between 0 and 35°C; water depths from a few centimetres to 9 meters; low light to full sun; and a wide range of acidity and nutrient levels.

Potential negative impacts of hydrilla span the range of environmental, economic and social conditions. Hydrilla can dominate freshwater systems displacing indigenous biodiversity (charophytes, pond weeds, milfoils, shags, smelts and common bully), necessitate chemical use and increase flooding and erosion risk by clogging waterways. Water quality is reduced by lowering water circulation, reducing light and oxygen availability and the carbon uptake cause quite large pH fluctuation. Economic impacts include clogging of irrigation and hydro power systems, increased costs for fishers, reduced tourism and increased eradication, control, surveillance, monitoring and public awareness costs to managers of water systems. Social impacts include reduced recreational activity, and negative impacts on public health and Maori cultural and spiritual matters (MAF 2008b, Hofstra & Champion 2006a, ISSG 2006 and Clayton 2008a/pers comm).

In conjunction with Biosecurity New Zealand, we chose Lake Rotoroa as the freshwater system under threat. Lake Rotoroa was chosen as it has a higher risk of hydrilla invasion than the other two lakes, has a long history of management, has a high profile due to shoreline housing and recreational use and has some indigenous biodiversity similar to other New Zealand lakes (Harrison pers. comm., 2008). This lake has features typical of many lakes in New Zealand that make it useful to extrapolate from.

Setting up the experimental design involved four steps. Firstly, discussions with freshwater ecologists and biosecurity specialists captured scientific knowledge about the environment and the pest. Secondly, this information was tested with focus groups to obtain community views on what is important to them about the lake environment and the ranges of the key attributes, including the cost to their household for different levels of the environment. Thirdly, a basic design was formulated based on the scientific and focus group information and this was tested with a convenience sample. Finally, the priors (coefficients for each environmental and price attribute) from the test sample were incorporated into a Bayesian design to maximise efficiency for WTP estimation. The result was a questionnaire that had 12 choice questions for each respondent blocked into five different groups randomly allocated to respondents.

The results were obtained for a simple Multi Nomial Logit (MNL) model before testing the more sophisticated Random Parameters Logit (RPL) models (also known as Mixed Logit model) with varying assumptions on distributions. We found that using a normal distribution to describe environmental attributes produced illogical results (negative WTP in some cases due to fat tails). A truncated triangular distribution, where the standard deviation is limited to the mean value, was used to overcome this problem. The RPL panel model is superior to MNL as it allows for each respondent to have different views while retaining consistency for each respondent. The preferred RPL1 model (environmental attributes truncated triangular distributions and price fixed) had an excellent model fit for all locations equivalent to a linear R^2 of 70-80% and all attributes, except water quality, statistically significant at the 99% level of confidence.

Overall people were willing to pay more to avoid hydrilla infestation than to protect individual existing attributes of the environment. This is in line with the expected large negative impact of the weed and the likelihood that once in the lake there would be a high probability of it spreading to other waterways. Of the existing environmental attributes charophytes, which are of international significance and at high risk from hydrilla, rated highest followed by birds and fish and freshwater mussels.

Aggregating the mean WTP for the environmental attributes to the 2006 census household population resulted in a Net Present Value for 5 years for Compensating Surplus (CS) for all environmental attributes of $348 million for the Waikato region and $3 billion for New Zealand. These values have been estimated using a discount rate of 8%. Aggregation bias is caused by three main factors (Morrison, 2000): response rate, similarity of preferences of respondents and non-respondents, and correlation between preferences and socio-demographic characteristics (SDCs). Interaction variables of the income and membership in conservation group SDCs with the various attributes showed no significant effect on preferences.

Despite the lack of a statistical distance-decay effect, on-going work on aggregation issues may suggest a lower value for compensating surplus possibly due to such factors as non-attendance (where respondents may ignore a particular attribute such as cost in stating their preferences). Thus, aggregation based on mean WTPs needs to be treated with caution. There is also the issue of mental account, which is the point that people would not be willing to pay for every lake in New Zealand at the same amount as one lake. This casts doubts on the sense of aggregating values beyond the local or district level (Marsh, pers. comm., 2009). On the other hand biosecurity issues represent a special case. It may be that respondents outside the region are thinking that stopping the spread of a pest at the local level means that it will not spread to their region. This may explain their willingness to pay amounts similar to those at the local level. Decision makers need to apply judgement and common sense to such estimates and depending on the situation restrict aggregation of values to the appropriate level, be that local, district, region or national.

Including the impact of adjustments for aggregation bias for income and membership in conservation group resulted in a reduction of 28% and 41% in NPV respectively.

Incorporating uncertainty in the mean WTP estimates resulted in a 90% probability that the NPV for Rotoroa (local level) would be between $2.7m and $6.1m. Similar levels of uncertainty exist for the other results. The additional information that incorporating uncertainty into the analysis provides is that decision makers become aware of the uncertainty embodied in estimates and they can relate the extent of that uncertainty to the mean values.

The key conclusions of the study are:

- The choice experiment to estimate environmental values for a freshwater lake has provided statistically significant WTP values that could be used in a CBA.
- WTP declines the further one is away from the environmental asset in question, but this is not statistically significant at the 5% level.
- Correcting for potential aggregation biases results in a significant lowering in WTP values.
- Uncertainty embodied in the estimates of WTP values can be placed alongside and are not out of line with the uncertainty inherent in the estimates of physical damage from a pest incursion when constructing and reporting on the costs and benefits of different response options.

2 Introduction

This paper reports on a choice experiment to estimate Willingness To Pay (WTP) and Compensating Surplus (CS) for environmental attributes of a freshwater lake. It is part of a wider study to develop a value transfer database to be used by Biosecurity New Zealand (BNZ) in Cost Benefit Analysis (CBA) studies during pest incursions when time and money are constrained.

3 Background and rationale

The aim of the freshwater case study is to elicit dollar values of impacts on indigenous biodiversity due to a hypothetical incursion of an exotic weed from four population samples at varying distances from the incursion. The hypothetical question is the willingness to pay for maintaining or limiting deterioration of key environmental aspects of Lake Rotoroa (Hamilton Lake) due to the weed hydrilla with the focus on impacts on indigenous biodiversity. The payment vehicle for eliciting willingness to pay is a special tax on rate payers assessed annually for five years.

Biosecurity New Zealand has primary responsibility for weed and pest management in New Zealand including the detection and prevention of incursions, and surveillance and responses to incursions(Biosecurity_Council, 2003). As funding is limited a framework is needed to allocate available resources to maximise the effectiveness of biosecurity programmes so that net national benefit is also maximised. Cost benefit analysis has long been the tool used to quantify these net benefits where market prices are available to assess the impacts on industry and assist in making these resource allocation decisions (Treasury, 2008). But where there are no market prices, such as where pests impact on indigenous biodiversity, special tools are needed to estimate changes in dollar terms so that these values can be incorporated into CBA along side impacts on industry. As impacts on non-market values can be of a similar magnitude as market values, only then can the full impacts be weighed up and assessment made as to the appropriate action.

Choice modelling (CM) is the tool that has gained most credence to perform non-market valuation of environmental goods and services (Rolfe and Bennett, 2006). CM has emerged from utility theory and belongs to the suite of tools referred to as stated preference techniques as they rely on people stating their preference faced with a number of choices about changes to key attributes given some cost to them. The tool is well established internationally but has not been widely used in New Zealand in the natural resource area (Kerr, Sharp and Kaval 2006).

This project is one of four case studies aimed at establishing a database of non-market values of high priority ecosystems in terms of their vulnerability to incursions and that also have high biodiversity values. The four case studies are: South Island high country, coastal marine, beech forest and freshwater systems.

Paper outline

This paper provides:

- a summary of relevant background material on the ecology of freshwater systems, the case study pest (hydrilla), the ecosystem at risk (Lake Rotoroa) and pest management options
- the theory behind assessing lost value
- a description of the survey process for collecting value information
- the theoretical model and experimental design
- survey results, and
- discussion and conclusions on possibilities to transfer the results to other situations.

4 Freshwater ecosystem

In this section we summarise the main ecological aspects of freshwater systems that are important to establish the nature, quality and quantity of key attributes impacted on by pest incursions. These aspects are covered in detail in a separate paper by Cudby and Bell (2008). This document also provides contextual information to help with future assessment of feasibly extrapolating the results of this case study to other lakes and other pest species. Clayton (2008c pers. comm.) emphasises that each lake is unique and such a decision about extrapolating case study results would need to be carefully made based on an explicit consideration of Lake Rotoroa's characteristics, the characteristics of other lakes for which the results are to be extrapolated to and the potential impact of hydrilla on that lake. Clayton (2008c pers. comm.) suggests that one approach could be (for example) to rank all water bodies on a 0-5 scale as to how much impact hydrilla could potentially have.

A clear understanding of the ecology is necessary to develop presentations for both the focus groups and surveys, design the choice-modelling survey, inform analysis about key attributes of Lake Rotoroa's environment and the levels of those attributes, inform analysis about a hypothetical incursion of hydrilla on Lake Rotoroa, the impacts and options to manage those impacts.

Fresh water ecosystems and their biodiversity include lakes, rivers, underground waterways, wetlands and all the species that live there. New Zealand's freshwater ecosystems are rich in indigenous biodiversity due to 80 million years of geographic isolation. The level of threat from pests varies depending on the level of human access and activity. For example, wetlands contain particularly high levels of biodiversity, but just over 10% of the original wetland habitat remains with less than half of this under protection (MfE 2007). Key species such as submerged deeper water plants (e.g. charophytes and bryophytes), which are internationally significant are under very high risk from exotic submerged plants. But it is difficult to assess just how much under threat - as traditional measures tend to be terrestrial based and not appropriate to freshwater ecosystems (Clayton pers. comm. 2008b).

Freshwater biodiversity and the health of the freshwater ecosystems are interdependent. Land use in a catchment affects the amount of water, nutrients, sediment and other contaminants entering a lake. Factors affecting lake water quality are complex. For example, increased nutrient levels initially encourage algae and other exotic plants to grow reducing light for native species, but at high levels may cause toxic algal blooms with much more serious consequences on the whole ecosystem.

These fresh water systems which start with plankton and aquatic plants, leading to invertebrates such as freshwater crayfish (koura) and mussels, as well as a range of insects and end with fish and birds are economically, socially and environmentally important. Uses and functions include direct consumptive (e.g. drinking water), direct non-consumptive (e.g. recreation), indirect (e.g. water purification), and other values including option, existence and bequest values.
New Zealand has very diverse lake types including artificial (e.g.hydro lakes), coastal barrier, dune, glacial, landslide, river and volcanic (Nathan 2007). Water can stay in lake basins for long periods, making lakes vulnerable to human activities. Lake water quality is affected by many interconnecting factors including land use in a catchment, stability of lake sediments and composition of the submerged flora and fauna.

Many freshwater lakes species have been significantly reduced in distribution. The ecosystems they depend on are severely under threat. New Zealand has internationally recognised communities of the submerged plants species such as charophytes under threat. There are very few totally indigenous lakes and many are ecologically degraded.

Threats to lake biodiversity are due to habitat loss and degradation through urban pressures, rural land use and lack of vegetation along waterways. Pests cause further habitat loss and displacement of native species.

New Zealand's lowland freshwater ecosystems are least protected with not as much conservation undertaken compared with other ecosystems. The majority of exotic species were deliberately introduced into New Zealand, but now that New Zealand's borders are well governed from a biosecurity point of view the introduction of new species is limited. The major pathway in the movement of existing weed fragments is people; either deliberate from ornamental planting, aquarium liberation or accidental through transport of contaminated water-craft and trailers, fishing nets, or drainage equipment (MfE 2002a; Clayton & Champion 2003).

It is the alien submerged plant species that have been the most invasive, difficult to control, and continue to pose the most significant threat to our freshwater biodiversity. The most problematic of these are the oxygen weeds (*Elodea canadensis, Egeria densa, and Lagarosiphon major*), hornwort (*Ceratophyllum demersum*) and hydrilla *(Hydrilla verticillata)*, because they grow taller and faster than native species. The dense single-species (sometimes surface-reaching) beds they form can significantly alter freshwater habitat displacing native species (NIWA 2003; Closs et al 2004; Champion & Clayton 2000).

Preventing ecosystem damage is cheaper than repairing damage afterwards. A key factor for aquatic species is that the extent of the impact of the invasive is largely undetectable by most people until the species is well established. There are still sizeable gaps in our knowledge, but surveys show the public now rate freshwater issues as the most important environmental problem facing New Zealand (Green and Clarkson 2005).

The management of freshwater pests is undertaken by many organisations and groups. BNZ is the lead agency. Others involved range from other central government agencies, regional councils, industry, community groups and the general public (MAF 2008a). Who is involved and what they do depend on the particular pest, its impacts and response options.

5 Case study: Hypothetical weed incursion

5.1 Case study weed - hydrilla

Hydrilla was chosen as the case study invasive as it is BNZ's top priority weed. Although restricted to only three lakes in Hawkes Bay area it has the greatest potential for negative impacts on New Zealand's freshwater systems. Two other species were considered - hornwort and didymo (*Didymosphenia geminata*). Hydrilla won out as hornwort is already naturalised throughout the North Island and didymo, while having been subject to a major public awareness campaign, has no other practical control mechanism.

Hydrilla is a submerged freshwater perennial plant that is characterised by prolific growth and tolerance of a wide range of freshwater habitats from clear, murky, still or flowing water; temperature between 0 and 35°C; water depths from a few centimetres to 9 meters; low light to full sun; and a wide range of acidity and nutrient levels.

Hydrilla has many branches and can form a dense, single species canopy (especially in waterways that are highly disturbed by human activities) that can reach the surface from depths of 4 meters. Its stems are thin and can grow up to 9m long. While it is usually rooted to the substrate, it can grow as surface floating mats. While hydrilla has not exhibited signs of flowers or seeds in New Zealand lakes it propagates very easily from stem fragments, turions (detachable leaf buds) and tubers. These latter two mechanisms are what make hydrilla a major pest. The turions can spread quickly throughout a waterway and survive for 1-2 years while the tubers can survive for possibly up to ten years. Both turions and tubers can survive ice cover, drying, ingestion and regurgitation by water fowl, and herbicide use (Hofstra & Champion 2006a, ISSG 2006 and NIWA 2007b).

Figure 1: Hydrilla stem and weed mat

The main mechanisms for spreading hydrilla are boating and fishing activities rather than water fowl or other natural means such as wind. And so the banning of motorised boats and commercial eeling with associated public awareness campaigns on the three infested lakes have no doubt prevented the spread of hydrilla throughout New Zealand (Hofstra & Champion 2006a and NIWA 2007b).

Potential negative impacts of hydrilla span the range of environmental, economic and social conditions. Hydrilla can dominate freshwater systems displacing indigenous biodiversity (charophytes, pond weeds, milfoils, shags, smelts and common bully), necessitate chemical use and increase flooding and erosion risk by clogging waterways. Water quality is reduced by lowering water circulation, reducing light and oxygen availability and the carbon uptake cause quite large pH fluctuation. In addition, swans flock to areas with submerged aquatic plants, and they tend to be polluting and aggressive with other fauna and people - especially children. Economic impacts include clogging of irrigation and hydro power systems, increased costs for fishers, reduced tourism and increased eradication, control, surveillance, monitoring and public awareness costs to managers of water systems. Social impacts include reduced recreational activity, and negative impacts on public health and Maori cultural and spiritual matters (MAF 2008b, Hofstra & Champion 2006a, ISSG 2006 and Clayton 2008a/pers comm).

5.2 Case study ecosystem – Lake Rotoroa

In conjunction with Biosecurity New Zealand, we chose Lake Rotoroa as the freshwater system under threat. Two other lakes (Waikaremoana and Wanaka) were considered for study. Lake Waikaremoana while the North Island's highest value lake is isolated, has a low profile and low risk from human activity. On the other hand, Lake Wanaka, while high profile, is heavily influenced by tourism rather than biodiversity values. Lake Rotoroa was chosen as it has a higher risk of hydrilla invasion than the other two lakes, has a long history of management, has a high profile due to shoreline housing and recreational use and has some indigenous biodiversity similar to other New Zealand lakes (Harrison pers. comm., 2008).

This lake has features typical of many lakes in New Zealand that make it useful to extrapolate from. It forms the focus for the city's largest park and is in an urban setting with high recreational use, both active (sailing, rowing, paddling, fishing and ground sports) and passive (walking, bird watching, contemplating), but because of water quality issues swimming in the lake is not encouraged. The lake is largely surrounded by houses (25% of the catchment), but there is public access right around the lake and there are playgrounds and a reserve making up 35% of the catchment. The lake area itself is 54 ha (40% of the catchment), contains 1.3 million m^3 of water and has a total catchment of 138 ha. Resident time of water in the lake is about 2 years. The maximum depth of water is 6m with an average depth of 2.4m and a surface water temperature range of 9-25^{o}C. It is one of a series of 31 shallow peat lakes concentrated around the Waikato Waipa districts and is 37m above sea level. Before European settlement like most of the peat lakes it had no inlet or outlet with water levels determined by rainfall and evaporation. Now that the lake acts as a sink for urban storm water runoff water from the lake drains into a stream and eventually enters the Waikato River. (Clayton & de Winton 1994, Tanner et al 1990, EW 2008a and HCC 2006).

Figure 2: Lake Rotoroa (Hamilton Lake)

Hamilton City Council has responsibility for the lake's management which focuses on protecting the natural environment while providing for public access, outdoor recreation and open space. Lake water quality has been improving in recent years but is still nutrient enriched and phosphate limiting. This means that the abundant phytoplankton are kept in check. Heavy metals from urban run off and past chemical treatment are present but within water quality guidelines and have little impact of the lake's biota. There have been previous invasions of oxygen weeds and Egeria is the current dominant species although under control from past physical removal and the last spray programme in 2005. Native charophytes, which stabilise bottom sediments, have been significantly reduced in area but are now settled at around 21% of the lake bed. Around the lake edge previous beds of yellow flag iris are being gradually replaced by plantings of native grasses, sedges and bull rushes. There are small areas of water lilies and control is recommended. (Tanner et al 1990, Clayton & de Winton 1994, de Winton, Wells & Wilding 2005, HCC 2006, de Winton et al 2007).

Lake Rotoroa has diverse fish fauna by New Zealand standards; six exotic fish species (goldfish, rudd, tench, brown bullhead catfish, mosquitofish and perch) and four native species (shortfinned and longfinned eels, common smelt and common bully) are found. Exotic fish were stocked for recreational fishing (Clayton & de Winton 1994; HCC 2006). Freshwater mussels were once abundant, but disappeared over time. In 2001, 3000 mussels were re-introduced and in 2007 a survey found 65 remaining. It is hoped they will grow in number, but the presence of arsenic traces from previous weed spraying may be limiting.

Bird life around the lake is dominated by exotic mallard ducks (90% of bird life). Other species include Australian coot (3%), pukeko (1%) and four species of native shag (1.5%, comprising large black, little black, little and pied shags). Other birds are typical city dwellers such as pigeons and sparrows. Black swans which were once present in large numbers are only occasionally sighted and depend on the oxygen weed for food. Bird watching and feeding is a major public attraction around the lake, but the associated increases in numbers of birds and ducks in particular has negative impacts through faeces pollution. (de Winton et al 2005, HCC 2006, Clayton pers comm 2008b).

5.3 Hypothetical incursion of hydrilla

The threat of hydrilla to the lake ecosystem is far greater than that of the current exotic incursions of oxygen weeds. It would likely develop into extensive weed beds at all depths and smother the native charophytes in particular. While eels are likely to be unaffected the remaining species of native fish and mussels would be severely impacted on through a reduction in available space and change to the habitat. It is also likely that the shags would stop frequenting the lake as the areas of clear water reduced. Swans would be attracted and this would help clear water to a depth of around 1m, but their aggressive behaviour particularly towards children has a down side. Boating would be severely hindered.

If hydrilla was ever introduced to Lake Rotoroa and became well established there is no realistic prospect of elimination without the long term use of grass carp. A small incursion detected early could be controlled with the herbicide endothall, or other methods such as weed matting but use of these techniques will depend very much on where the specific incursion is, and how established it has become. As hydrilla would eliminate all native vegetation anyway, especially charophytes and the underlying seed beds, the use of grass carp would be justified to prevent irreversible damage to the lake ecosystem. Hence the best management strategy is to target effort towards investing in preventing the introduction of hydrilla, or eradicating hydrilla before it became established (de Winton et al 2005; Clayton 2008a pers comm.; Hofstra 2008 pers. comm.).

5.4 The economic problem

It is clear that the introduction of hydrilla into Lake Rotoroa would result in very serious impacts on indigenous biodiversity as well as on how humans would interact with the lake. Thus the benefits of eradication or control of hydrilla are the negative impacts avoided. The negative impacts include loss to the lake of native species and in particular charophytes, fish, mussels and birds. As the clarity and quality of the water progressively become reduced this would have increasing negative impacts on humans through reduction in the quality of the experience of visiting the lake for boating, a gross deterioration in the view presented and eventually odour issues.

As pointed out above the ability to eradicate or control an infestation are dependent on prevention and early detection. Depending on the management strategy adopted different states of the ecosystem are possible. The attributes associated with the different states of the ecosystem become the basis for framing the choices put to survey participants. Through carefully constructed questionnaires which present participants with alternative choices of the attributes of the ecosystem along with a money cost to their household it is possible to elicit their willingness to pay (WTP) for a particular state of the environment. This forms a proxy for the value of a change to the ecosystem, which is necessary in order to include environmental values into cost benefit analysis.

6 Survey design and data collection

6.1 Questionnaire design

Having set the context, the first step in the questionnaire design is to find out what biodiversity-related attributes of the ecosystem and the levels of those attributes that are important to people. This was done using focus groups arranged by a professional market research agency. Groups were convened in Wellington and Hamilton in April 2008. Participants did not know the purpose of the study until they arrived at the meeting. Prior to this the focus group presentation was tested with a group from Biosecurity New Zealand to ensure the technical aspects were accurate.

The first part of the focus group session was a presentation to introduce the concepts of freshwater biodiversity, the threats to lake biodiversity and biodiversity protection and control measures. Next we introduced the case study lake and described its features using slides to depict the various attributes of the lake including natural and man made aspects. We then asked participants to make a choice between two different states of various aspects of the lake. The idea here was to determine which features of the lake people valued most highly. Aspects covered included water with and without surface plants, board walk versus natural lake edge, ducks versus pukeko (exotic v native), oxygen weed versus charophytes (exotic v native), a scene with boats compared with birds on the lake, and a scene of the lake side with introduced trees versus native trees.

The next stage introduced hydrilla, the potential invasive weed, its characteristics and likely impacts. We then asked participants to indicate how acceptable different states of the environment would be to them. We tested water quality and clarity, presence of hydrilla, presence of native water plants (charophytes), presence of native fish and mussels, native birds, water sports and lake side recreation. Finally we asked participants to consider various increases in their annual rates bill for different control mechanisms resulting in different outcomes.

On the basis of the information collected at the three focus group meetings a draft questionnaire was drawn up and tested on a convenience sample of 12 people in June 2008. The results were analysed and used as the priors to assist in the statistical design of the survey proper.

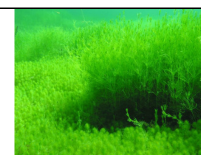
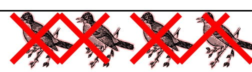
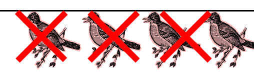
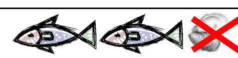
In the survey itself the participants were also primed prior to being presented with the choice questions. Participants were given a presentation which introduced the concepts of freshwater biodiversity and biodiversity protection, the case study lake and hypothetical hydrilla incursion, and the range of impacts that hydrilla could have on the ecosystem (see Appendix 3 and 4 for presentation slides and speech notes). Participants were then asked to provide answers to 12 choice questions. An example of a choice set is shown in Figure 3. The rows represent the attributes, for example, water quality and clarity, coverage of native submerged plants etc, and the columns represent the options or scenarios, which are described by a set of attribute levels including the cost to the participant's household.

The money attribute was "the cost to your household each year for 5 years". The payment vehicle was a household rate levied to fund hydrilla control, as provided for under the Biosecurity Act (1993). Money values were chosen to cover the range of payments likely to be acceptable based on the focus group results being $0, $10, $20, $40, $80 or $160.

Figure 3: Example of a Choice Set

Question 1:

Options A, B and C
Please choose the option you prefer
By ticking ONE box

	Option A	**Option B**	**Option C**
Extent of hydrilla	 100% coverage	 30% coverage	No hydrilla
Water quality and clarity	Significant deterioration	OK Same as now	OK Same as now
Coverage of native submerged plants	Eliminated from lake	Eliminated from lake	 Same as now at 21% cover
Number of native bird species	 All 4 shag species do not visit the lake anymore	 3 shag species do not visit the lake anymore	 3 shag species do not visit the lake anymore
Fish and mussels	 2 fish species and mussels disappear from the lake	 Mussels disappear from the lake	 1 species of fish and mussels disappear from the lake
Cost to your household each year for 5 years	$0	$160	$20
I would choose ☑	☐ A	☐ B	☐ C

6.2 Attributes

The attributes considered were:

HYD	Percentage of success in preventing hydrilla cover (0%, 35%, 70% and 100% success levels)
CHA	Percentage of success in preserving charophytes cover (0%, 7%, 14% and 21% success levels)
BIR	Number of shags species visiting the lake (0,1, 2 and 4 species)
FISHMUS	Number of fish species and mussels retained (0, 1, 2 and 3 species)
WQ1, WQ2, WQ3	Effects coding for 4 levels of water quality (significant, moderate or slight deterioration, or same condition from current quality and clarity of water)
PRICE	The money attribute was set at 6 levels: $0, $10, $20, $40, $80, $160 and presented as the cost to the respondent's household each year for the next 5 years.

6.3 Experimental design

Efficient design of surveys results in reliable parameter estimates characterised by small standard errors. The experimental design is Bayesian in nature using the normal distribution for the coefficients of all environmental attributes and the money coefficient. The design generated priors from a convenience survey of 12 respondents. As discussed in Ferrini and Scarpa (2007) a Bayesian efficient design is less sensitive to misspecifications of the priors than a point efficient design. The MNL estimates of the parameters from the convenience survey (see Table 1) were used as priors (where significant at 95% confidence level, otherwise theoretical prior is used) for the experimental design, which were assumed to be normally distributed with standard deviation equal to the estimated standard errors. For example, the design ignored the negative BIRDS1 coefficient and this was set close to zero with large variance in the Bayesian prior. The variables are dummy coded with respect to status quo (level 0). The criterion to be minimized was the sum of the variances of the marginal WTP of each attribute, as suggested in Scarpa and Rose (2008).

Table 1: MNL estimate convenience survey

Variable	Coefficient	Standard Error	P[|Z|>z]
HYDR1	0.8814*	0.5047	0.0807
HYDR2	1.1512**	0.5371	0.0321
HYDR3	2.1230***	0.5621	0.0002
WQUAL1	0.7167	0.5082	0.1584
WQUAL2	0.5628	0.5283	0.2867
WQUAL3	0.2473	0.4903	0.6140
CHAR1	1.3297**	0.5441	0.0145
CHAR2	2.3927***	0.6032	0.0001
CHAR3	3.1035***	0.5812	0.0000
BIRDS1	-0.1871	0.5544	0.7358
BIRDS2	0 .2586	0.4947	0.6011
BIRDS3	1.5754***	0.5149	0.0022
FISH1	0.3807	0.5470	0.4864
FISH2	1.3063**	0.5114	0.0106
FISH3	1.7579***	0.4870	0.0003
PRICE	-0.0206***	.0044	0.0000
LL			-64.545
Pseudo-R^2			0.382
AIC (Akaike information criterion)			1.134
BIC (Bayesian information criterion)			1.467

*** Significant at 99% confidence level
** Significant at 95% confidence level
* Significant at 90% confidence level

The algorithm for the experimental design minimises the sum of the variances of the WTP for the various policy attributes. As a result, the design is specific to WTP estimation (*C*-efficiency), rather than to estimation of parameter estimates (*D*-efficiency). See Scarpa and Rose *op cit* for review of these efficiency criteria. The recent release of Ngene[1], an experimental design software for stated choice experiments, allowed the evaluation of the survey design for efficiency. The evaluation result showed that the design is efficient with an S estimate 4.156 and D-error of 0.022. While the S estimate implies that the minimum sample size required is 5 respondents for the most difficult attribute to estimate, bias errors necessitate higher sample sizes. Bias arises from random choice behaviour and

[1] Version 1.0.0 © 2009 Rose, Collins, Bliemer and Hensher.

the assumption that all random components are independent (the IID assumption in MNL). However, the low S estimate achieved indicates an efficient design (ChoiceMetrics, 2009).

The status quo is the do nothing option with a payment of zero dollars and with all environmental attributes as the worst level. The status quo is presented as Choice A in all choice situations. Two alternatives to the status quo (Alt1 and Alt2) are presented as Choice B and C, respectively, in the survey questionnaire.

The optimal design comprises 60 choice sets. These were randomly divided into five groups resulting in a manageable grouping of 12 choice sets per respondent. The five groups of choice sets are uniformly distributed in each survey sample resulting in each group of choice situations being (more or less) uniformly represented. Please refer to Appendix 1 for the complete experimental design and coding of levels for the environmental attributes.

6.4 Data collection

The survey samples were drawn from four locations with varying proximity to Lake Rotoroa. The four samples are Rotoroa (sample beside or near the lake), Rototuna (sample in Hamilton - same city as the lake), Morrinsville (sample in Waikato – same region as the lake) and Karori (sample in Wellington – a distant urban location). The four locations were chosen to observe the effect of distance-decay for any of the attributes.

Typical methods for data collection include paper mail-out surveys, telephone surveys, internet surveys and personal paper or computer-aided design interviews. Telephone surveys involve huge cognitive burden as each questionnaire involves 12 choice sets with three options across six attributes per choice set. Impersonal mail-out surveys are unable to convey richness of information to a similar level achieved in a personal interview (Kerr and Sharp, 2003). Personal interview ensures respondent understanding of the survey and allow the use of visual aids to convey information but is the most expensive form of data collection particularly in multiple locations.

This study implemented a hybrid community meeting approach that involved a 40 minute presentation of the freshwater biodiversity and the case study lake and hydrilla incursion followed by 20 minutes for answering the choice sets (see Appendix 3 and 4 for presentation slides and speech notes). The hybrid approach has the advantage of bringing the assembled group of respondents to a uniform level of understanding of the issue and administering choice questionnaires to multiple respondents in one sitting.

Community service groups (e.g. school, dragon boating association, Lions or Rotary) were tapped to organise the community meetings with a target of 50-60 participants using a promotional flyer (see Appendix 5 for flyer sample), a $50 donation per person recruited and $20 petrol voucher to the participant. The community service groups were requested that a cross-section of adults in the community be invited with a gender balance, and a range of ages, educational qualifications, incomes and ethnicity.

7 Model specification

The generic utility of policy alternative *j* for respondent *n* in choice task *t* is defined as:

$$U_{jnt} = V(\boldsymbol{\beta}_n \mathbf{x}) + \varepsilon_{jnt} = \beta_{1n} HYD_{jnt} + \beta_{2n} WQ1_{jnt} + \beta_{3n} WQ2_{jnt} + \beta_{4n} WQ3_{jnt} + \beta_{5n} CHA_{jnt} + \beta_{6n} BIR_{jnt} + \beta_{7n} FISHMUS_{jnt} + \beta_{\$} PRICE_{jnt} + 1(1\text{-}SQ)\eta_n + \varepsilon_{jnt}$$

Where β_{kn} denotes random (across people, or n) taste intensities for attribute k, η_n is a random normal error component with zero mean entering the utility of the experimentally designed policy scenarios (the non-SQ alternatives), and ε_{jnt} is the Gumbel distributed error component.

Given $\boldsymbol{\beta}_n$ and η_n the probability of observing alternative i to be selected from the J alternative in the choice task is logit and the sequence of t choices made by a respondent is a joint logit or:

$$\Pr(i_1, i_2, i_3, \ldots, i_t \mid \beta_n, \eta_n) = \prod_t \Pr(i_t \mid \beta_n, \eta_n) = \prod_t \frac{\exp(\beta_n ' x_{jnt} + \eta_n)}{\sum_{j=1}^{J} \exp(\beta_n ' x_{jnt} + \eta_n)}$$

To obtain the unconditional probability the random components need to be integrated out over their respective ranges:

$$\Pr(i_1, i_2, i_3, \ldots, i_t) = \int_{\beta_n} \int_{\eta_n} \prod_t \frac{\exp(\beta_n ' x_{jnt} + \eta_n)}{\sum_{j=1}^{J} \exp(\beta_n ' x_{jnt} + \eta_n)} f(\beta_n, \eta_n \mid \boldsymbol{\mu}, \boldsymbol{\Omega}) d\beta_n d\eta_n$$

In our case the assumed distributions are normal with mean vector $\boldsymbol{\mu}$ and variance covariance $\boldsymbol{\Omega}$, only the mean of η_n is restricted to zero.

In the maximum simulated likelihood estimation, these integrals were approximated by weighted probability averages based on quasi-random draws from prime numbers i.e. Halton draws (Train, 2003) to take advantage of their good coverage properties and reduce the number of necessary draws to achieve high precision.

8 Results

8.1 Data

The freshwater survey gathered a total of 225 respondents from Rotoroa (lake side), Rototuna (Hamilton), Morrinsville (Waikato) and Karori (Wellington). Twelve under-age participants in the Rotoroa sample (under 18 years old) were excluded as it was considered the money issue would not be relevant as they would be unlikely to be a party to household budget decisions. This resulted in a total of 213 respondents distributed among Rotoroa (44), Rototuna (40), Morrinsville (65) and Karori (64) Overall, the analysis consisted of 2,556 observations.

The community meeting approach is not intended to generate a representative sample of each community. However, it is a good representation of an informed community such as the scenario that will exist following a community awareness campaign and debate about management options for a hydrilla incursion. We discuss the socio-demographic characteristics in the next paragraph to provide transparency on sample characteristics.

Population samples are generally representative of the relevant population (refer to Table 2 below) for some aspects (e.g. gender in Rototuna and Karori; young and mid-age in Morrinsville and Karori; low income in Rotoroa and high income in Rototuna, European/Asian ethnicity and high/low skills in Rototuna). In terms of gender, male is over-represented in Morrinville. Polytech and degree qualifications are generally over-represented in all samples. The old and young age groups are generally under-represented except in Karori (where old is over-represented). Except in Rototuna, the European ethnicity is over-represented. The Maori and Pacific ethnicities are over-represented in Rotoroa and Rototuna but under-represented in others. Asian (except in Rototuna) and other ethnicity is generally under-represented. The high income group and high-skill occupation group are generally over-represented except in Rototuna.

Respondents were asked to indicate whether they were a member of a conservation group and this resulted in positive responses for Rotoroa (23 %), Rototuna (8 %), Morrinsville (14 %) and Karori (16 %).

Table 2: Survey demographics

	Sample				Population Census				Lower Limit				Upper Limit			
	Rotoroa	Rototuna	Morrinsville	Karori	Rotoroa	Rototuna	Morrinsville	Karori	Rotoroa	Rototuna	Morrinsville	Karori	Rotoroa	Rototuna	Morrinsville	Karori
GENDER																
Male	40.9%	42.5%	66.2%	51.6%	48.3%	48.5%	49.1%	47.7%	41.2%	41.0%	43.2%	41.8%	55.4%	56.0%	55.1%	53.5%
Female	59.1%	57.5%	33.8%	48.4%	51.7%	51.4%	50.9%	52.3%	44.1%	43.5%	44.7%	46.0%	59.3%	59.3%	57.0%	58.7%
QUALIFICATION																
No Qual	0.0%	0.0%	4.6%	1.6%	14.7%	16.3%	31.2%	7.8%	12.5%	13.8%	27.4%	6.9%	16.9%	18.8%	35.0%	8.8%
Fifth	9.1%	10.3%	4.6%	1.6%	9.5%	12.8%	16.5%	7.1%	8.1%	10.8%	14.5%	6.3%	10.8%	14.8%	18.5%	8.0%
Sixth	20.5%	12.8%	6.2%	1.6%	22.8%	24.3%	18.4%	25.2%	19.5%	20.6%	16.2%	22.1%	26.2%	28.0%	20.6%	28.3%
Polytech	38.6%	33.3%	56.9%	34.4%	19.3%	21.5%	17.1%	15.1%	16.5%	18.2%	15.0%	13.3%	22.1%	24.8%	19.1%	17.0%
Degree	31.8%	43.6%	27.7%	60.9%	24.8%	19.5%	6.4%	40.4%	21.2%	16.5%	5.6%	35.5%	28.5%	22.5%	7.1%	45.3%
AGE																
Young	22.7%	11.4%	35.4%	17.2%	35.2%	19.3%	21.8%	18.2%	30.0%	16.3%	19.1%	16.0%	40.4%	22.2%	24.4%	20.4%
Mid-age	77.3%	75.0%	46.2%	57.8%	47.9%	58.5%	51.8%	62.5%	40.9%	49.5%	45.5%	54.9%	55.0%	67.5%	58.0%	70.2%
Old	0.0%	2.3%	18.5%	25.0%	16.9%	22.3%	26.5%	19.3%	14.4%	18.9%	23.3%	16.9%	19.3%	25.8%	29.7%	21.6%
INCOME																
High income	31.8%	35.0%	43.1%	57.8%	22.1%	32.6%	13.7%	37.0%	18.9%	27.6%	12.1%	32.5%	25.3%	37.5%	15.4%	41.5%
Low income	68.2%	65.0%	56.9%	42.2%	62.3%	55.4%	72.1%	52.0%	53.2%	47.0%	63.4%	45.7%	71.4%	63.9%	80.8%	58.3%
ETHNICITY																
NZ European	70.5%	67.5%	90.8%	89.1%	60.3%	68.4%	72.4%	72.6%	51.4%	57.9%	63.6%	63.8%	69.2%	78.9%	81.2%	81.5%
NZ Maori	22.7%	12.5%	3.1%	0.0%	13.2%	7.2%	12.2%	5.0%	11.3%	6.1%	10.8%	4.4%	15.2%	8.3%	13.7%	5.6%
NZ Asian	0.0%	10.0%	1.5%	6.3%	13.7%	11.7%	2.7%	14.6%	11.7%	9.9%	2.4%	12.8%	15.7%	13.5%	3.0%	16.3%
NZ Pacific	4.5%	2.5%	0.0%	0.0%	2.6%	0.6%	1.0%	4.0%	2.2%	0.5%	0.8%	3.6%	3.0%	0.7%	1.1%	4.5%
Others	2.3%	7.5%	4.6%	4.7%	10.2%	12.1%	11.7%	3.8%	8.7%	10.2%	10.3%	3.3%	11.7%	13.9%	13.1%	4.3%
OCCUPATION																
High skill	38.6%	48.7%	27.7%	42.2%	45.5%	45.7%	36.0%	56.1%	38.8%	38.6%	31.6%	49.2%	52.2%	52.7%	40.3%	62.9%
Low skill	61.4%	51.3%	72.3%	57.8%	50.1%	52.3%	57.5%	39.9%	42.8%	44.3%	50.6%	35.0%	57.5%	60.4%	64.5%	44.8%

Source: Statistics New Zealand, 2006 Census area unit and territorial unit data

Definitions:

OLD	Over 60 years	HIGH INCOME	High-income (household income > $100,000 pa)
YOUNG	Under 30 years	HIGH SKILL	Occupation = managers or professionals
MIDAGE	30-60 years		

Relevant population:

Rotoroa – Hamilton Lake area unit
Rototuna – Rototuna area unit
Morrinsville – Matamata-Piako District
Karori – Karori North, Karori Park, Karori East and Karori South area units
Confidence intervals relate to the population. The sample needs to be within the lower and upper limit for 95% confidence level.

8.2 Modelling

8.2.1 Coding of attributes

The coding of the attributes for analysis reflects the change in the various levels for a particular attribute. For example, there is success in removing 35% of hydrilla cover in level 1 relative to the status quo (from 100% to 65% coverage, see Master Table in Appendix 1). Level 1 numeric coding is then 35 (see Table 3). Level 3 coding of 100 reflects total success in removing hydrilla.

Table 3: Numeric coding

Attribute	Level 0	Level 1	Level 2	Level 3	Description
HYD	0	35	70	100	Total success in removing hydrilla
CHA	0	7	14	21	Total success in preserving 21% charophytes cover
BIR	0	1	2	4	Total success in preserving 4 shags
FISHMUS	0	1	2	3	Total success in preserving 2 fish and 1 mussel (2+1=3)

Water quality utilised effects coding in order to account for non-linear effects in the attribute levels. The non-linear effects arise from differences in utility[2] between any two consecutive attribute levels (Hensher, Rose & Greene, 2005, pp 119-121). The four levels are coded into three variables as shown in Table 4.

Table 4: Effects coding

Water quality	WQ1	WQ2	WQ3
Level 0 - significantly worse than now	-1	-1	-1
Level 1 – moderately worse than now	1	0	0
Level 2 – slightly worse than now	0	1	0
Level 3 – OK, same as now	0	0	1

Reference: Hensher, Rose and Greene (2005), Applied choice analysis: A primer, page 121, Table 5.9.

[2] An analogy will be air travel where the difference between first class and business class is not the same as the difference between business class and economy.

8.2.2 Pooling test

Interacting the location variable with the environmental attributes (e.g. hydrilla, charophytes, birds, fishmussels and price) will reveal if location is significant in accounting for the variance in taste intensities. Interaction variables account for interaction where the preference for the level of one attribute is dependent upon the level of a second attribute (Hensher, Rose and Greene (2005), p 116). Rotoroa, as the sample nearest to the affected lake, was used as the baseline location in creating the interaction variables. The interaction variables show that there is no significant difference[3] accounted for by location in terms of the attributes hydrilla, water quality, charophytes, birds and fish-mussels. The interaction with the price attribute shows the Wellington interaction as significantly different from the Rotoroa, Hamilton and Morrinsville.

A complementary test for pooling is testing whether the unobserved error accounts for significant differences (Rose, 2009 pers. comm.). This test determines whether there is an error variance linked to choosing the status quo against the alternatives. Using this test for the Waikato region samples showed a significant error term at 99% confidence level. This means that the different locations are different due to the unobserved error.

8.2.3 Models

In choice experiments, we observe the choices made by individuals, the attributes of the alternatives they choose and the characteristics of the individuals. Assuming utility maximising individuals, choice models represent the true but partially observed decision rule adopted with a probability of selecting that alternative which maximises relative utility.

We tested two models: the standard Multi Nomial Logit (MNL) model and the panel version of the Random Parameters Logit (RPL) model (also known as Mixed Logit model). The standard MNL model assumes that respondents have similar preferences (i.e. unexplained error terms are Independent and Identically Distributed (IID)). The RPL model relaxes the most restrictive assumptions and increases the explanatory power of the model by allowing for heterogeneity of individual utility for the attributes, correlation among attributes, and variance in choosing among alternatives (alternative1 and alternative2 vs. status quo). The heterogeneity of individual utility has been constrained to be negative for environmental attributes. Parameters that exceed zero (i.e. long tails in the

[3] The no significance test was based on the mixed logit model. The MNL model showed significant difference in more attributes (i.e. Hyd_H and Bir_H where 'H' is the location Hamilton).

distribution) are assumed to be zero utility. This is addressed by constraining the standard deviation to be a function of the mean (Hensher, Rose and Greene, 2005). The triangular distribution constrained to value of 1 (which forces the mean to equal to the spread of the distribution) was specified for the environmental attributes.

We used intelligent Halton draws to derive the estimates as this process only requires one-tenth the number of draws compared with simple pseudo-random draws (Bhat, 2001 cited by Hensher, Rose and Greene, 2005, pp 614 - 616). A total of 150 draws were used in the estimation.

The results of the four models are summarised in Table 5 and 6 (Rotoroa, Hamilton, Morrinsville and Wellington models). Both tables present the coefficient mean and standard deviation estimates and p-values of the parameters. The bottom part of the tables shows several tests of model fit. McFadden's pseudo-R^2 cannot be interpreted in the same way as the R^2 in a linear regression model. Pseudo-R^2 values between 0.3 and 0.4 represent acceptable model fit in a discrete choice model as these are translated as an R^2 of between 0.6 and 0.8 for the linear model equivalent (Hensher, Rose & Greene, 2005, pp 338-339). The model has better fit the higher the LL (log likelihood; i.e. less negative number or closer to zero). The AIC (Akaike information criterion) and BIC (Bayesian information criterion) are also tests of model fit that trade off improvements in LL with increasing number of parameters (i.e. a higher LL or a lower number of parameters leads to better AIC and BIC). The smaller the AIC and BIC, the better the model fit.

We tested the MNL and several variants of the RPL model. The RPL model with normal distribution for the environmental attributes and allowed for variance in choosing among alternatives yielded the best model fit with adjusted McFadden's R^2 for Rotoroa (0.468), Hamilton (0.390), Morrinsville (0.389) and Wellington (model included correlation among attributes: 0.439). However, this model did not perform well for willingness to pay specifically the range for the 95% confidence interval as it resulted in some attributes with lower limits that are illogical (i.e. negative WTP). The results of the preferred models are discussed below:

MNL. The standard MNL model resulted in all attributes except for water quality[4] being significant at the 99% level for the four models. Measures of

[4] WQ (water quality attribute) is considered significant if any one of the three WQ variables has a significant p value.

model fit for the Rotoroa data showed LL -329, AIC 1.279 and BIC 1.351, the Hamilton data showed LL -343, AIC 1.466 and BIC 1.544, the Morrinsville data showed LL -576, AIC 1.501 and BIC 1.555 while the Wellington data showed LL -525, AIC 1.392 and BIC 1.447.

RPL1. The RPL1 (Random Parameters Logit 1) model specified the truncated triangular distribution (i.e. mean is same as the spread) for the coefficient of the environmental attributes (i.e. all attributes except price which is a fixed parameter). Grouping the data into 149 panel groups (i.e. grouping each 12 choice sets as related to one respondent) and using 150 Halton draws resulted in a good adjusted McFadden's R^2 for all four locations ranging from 0.356 (Morrinsville) to 0.464 for Rotoroa. All attributes are significant for the four samples except for statquo in the Waikato region samples. Measures of model fit for the Rotoroa data showed LL -311, AIC 1.212 and BIC 1.285, the Hamilton data showed LL -333, AIC 1.425 and BIC 1.503, the Morrinsville data showed LL -552, AIC 1.439 and BIC 1.492 while the Wellington data showed LL -514, AIC 1.363 and BIC 1.417.

RPL2. The RPL2 model has similar specifications as the RPL1 model with the additional specification of random parameters for the alternatives (two alternatives and the status quo). This introduces a normally distributed random error term associated with alternatives. It resulted in a slight improvement in adjusted McFadden's R^2 in all samples except the Rotoroa model (ranging from 0.367 to 0.464). All attributes were significant except statquo and the error term in the Rotoroa and Hamilton models. The Wellington model also resulted in an improved McFadden's R^2 (0.409) and all attributes including the error term are significant except for the standard deviation of charophytes. Measures of model fit for the Rotoroa data showed LL -311, AIC 1.216 and BIC 1.297, the Hamilton data showed LL -330, AIC 1.412 and BIC 1.505, the Morrinsville data showed LL -542, AIC 1.416 and BIC 1.476 while the Wellington data showed LL -510, AIC 1.354 and BIC 1.414.

Table 5a: Rotoroa model coefficients and p-values

	MNL		RPL1		RPL2	
Variable	**Estimates**	**p-values**	**Estimates**	**p-values**	**Estimates**	**p-values**
HYD μ	2.2082***	.0000	3.4253***	.0000	3.4306***	.0000
WQ1 μ	-.1199	.5728	-.2294	.3359	-.2198	.3149
WQ2 μ	.3945*	.0663	.4659*	.0704	.4660*	.0745
WQ3 μ	.3546*	.0919	.5897**	.0145	.5852***	.0084
CHA μ	1.8003***	.0000	2.7479***	.0000	2.7613***	.0000
BIR μ	1.4810***	.0000	2.1998***	.0000	2.1956***	.0000
FISHMUS μ	1.1657***	.0000	1.9046***	.0000	1.9064***	.0000
σ_η	-	-	-	-	.6797	.9264
STATQUO	-1.7094**	.0375	-1.0248	.2179	-2.1245	.7538
PRICE	-.0084***	.0000	-.0136***	.0000	-.0101***	.0000

	MNL	RPL1	RPL2
LL	-328.547	-311.010	-310.961
Pseudo-R^2		.464	.464
AIC (Akaike information criterion)	1.279	1.212	1.216
BIC (Bayesian information criterion)	1.351	1.285	1.297

*** Significant at 99% confidence level, ** Significant at 95% confidence level, * Significant at 90% confidence level
Note: Standard deviation is the same as the mean.

Table 5b: Hamilton model coefficients and p-values

	MNL		RPL1		RPL2	
Variable	**Estimates**	**p-values**	**Estimates**	**p-values**	**Estimates**	**p-values**
HYD μ	1.3898***	.0000	2.1486***	.0000	2.0933***	.0000
WQ1 μ	.4250**	.0274	.4824*	.0712	.6042***	.0065
WQ2 μ	.4209**	.0369	.5441**	.0382	.6147**	.0115
WQ3 μ	-.0935	.6231	-.0222**	.9343	-.1356	.5003
CHA μ	1.3857***	.0000	2.0340***	.0000	1.8907***	.0008
BIR μ	.9064***	.0000	1.2856***	.0000	1.2185***	.0000
FISHMUS μ	1.1795***	.0000	1.6978***	.0000	1.6521***	.0000
σ_η	-	-	-	-	3.0854	.1184
STATQUO	-1.0823**	.0469	-.4893	.3571	-3.2378	.2519
PRICE	-.0078***	.0000	-.0115***	.0000	-.0112***	.0000

	MNL	RPL1	RPL2
LL	-342.849	-333.007	-330.213
Pseudo-R^2		.369	.374
AIC (Akaike information criterion)	1.466	1.425	1.412
BIC (Bayesian information criterion)	1.544	1.503	1.505

*** Significant at 99% confidence level, ** Significant at 95% confidence level, * Significant at 90% confidence level

Note: Standard deviation is the same as the mean.

Table 5c: Morrinsville model coefficients and p-values

	MNL		RPL1		RPL2	
Variable	**Estimates**	**p-values**	**Estimates**	**p-values**	**Estimates**	**p-values**
HYD μ	1.5211***	.0000	2.4480***	.0000	2.1631***	.0000
WQ1 μ	.0373	.7977	-.3652**	.0315	-.1778	.2326
WQ2 μ	.1909	.1949	-.0053	.9741	.0708	.6884
WQ3 μ	-.0722	.6193	.5377***	.0008	.3272**	.0300
CHA μ	.8252***	.0000	1.4771***	.0000	1.1502***	.0016
BIR μ	.8608***	.0000	1.3834***	.0000	1.2037***	.0000
FISHMUS μ	.7745***	.0000	1.2037***	.0000	1.0296***	.0000
σ_η	-	-	-	-	3.2231***	.0000
STATQUO	-1.1508***	.0037	-.6220	.1223	-3.7056***	.0071
PRICE	-.0063***	.0000	-.0100***	.0000	-.0087***	.0000

	MNL	RPL1	RPL2
LL	-576.387	-552.016	-542.192
Pseudo-R^2		.356	.367
AIC (Akaike information criterion)	1.501	1.439	1.416
BIC (Bayesian information criterion)	1.555	1.492	1.476

*** Significant at 99% confidence level, ** Significant at 95% confidence level, * Significant at 90% confidence level

Note: Standard deviation is the same as the mean.

Table 6: Wellington model coefficients and p-values

	MNL		RPL1		RPL2	
Variable	Estimates	p-values	Estimates	p-values	Estimates	p-values
HYD μ	1.5534***	.0000	1.9835***	.0000	2.0265***	.0000
WQ1 μ	.2377	.1394	.3775	.1049	.4301***	.0027
WQ2 μ	.4242**	.0108	.6777***	.0036	.7119***	.0000
WQ3 μ	.0303	.8487	-.0924	.6946	-.1379	.3684
CHA μ	1.3512***	.0000	1.6643***	.0000	1.6170***	.0001
BIR μ	1.3190***	.0000	1.6551***	.0000	1.6531***	.0000
FISHMUS μ	1.0511***	.0000	1.3147***	.0000	1.3350***	.0000
σ_η	-	-	-	-	2.5003***	.0000
STATQUO	-1.3340***	.0035	-.9760**	.0287	-2.8340**	.0337
PRICE	-.0107***	.0000	-.0129***	.0000	-.0130***	.0000

	MNL	RPL1	RPL2
LL	-525.588	-514.412	-509.801
Pseudo-R^2		.390	.396
AIC (Akaike information criterion)	1.392	1.363	1.354
BIC (Bayesian information criterion)	1.447	1.417	1.414

*** Significant at 99% confidence level, ** Significant at 95% confidence level, * Significant at 90% confidence level

Note: Standard deviation is the same as the mean.

8.3 Willingness to pay and confidence intervals

The willingness to pay (WTP) and confidence interval (at 95% level) of the environmental attributes for the Rotoroa, Hamilton, Morrinsville and Wellington samples under the MNL and RPL1 models are summarised in Table 7. Figure 4 shows the frequency distribution of the WTP. The WTP is generated from the parameter estimates of the environmental and price attributes. As this results in a WTP per unit change, the result has been normalised to represent total success in removing hyrdilla (x 100), preserving charophytes cover (x 21), preserving 4 shags (x 4) and preserving 3 fish/mussel species (x 3).

The WTP confidence intervals for the MNL models in the four samples have been calculated using the delta method (Greene, 2000). The delta method creates a linear approximation of the variance for functions of maximum likelihood estimates (Xu and Long, 2005)[5].

The confidence intervals for the RPL models were generated using parameter estimates for each of the 44, 40, 65 and 64 choices analysed (i.e. conditional parameter means) for the Rotoroa, Hamilton, Morrinsville and Wellington samples, respectively. The parameter estimates for each choice is not a specific individual estimate but a distribution resulting from 150 intelligent Halton draws. The mean and 95% confidence intervals were generated from this range of part worth estimates. Please refer to Appendix 2 for the conditional parameter means and WTP dataset[6].

Table 7: Willingness to pay and 95% confidence interval ($ per HH/ year)

	MNL				RPL 1			
Attribute	Rotoroa	Hamilton	Morrinsville	Wellington	Rotoroa	Hamilton	Morrinsville	Wellington
HYD	$ 262.46	$ 178.70	$ 240.56	$ 145.71	$ 243.71	$ 178.61	$ 233.81	$ 151.05
	(107, 418)	(66, 291)	(108, 373)	(86, 206)	(110, 378)	(89, 280)	(86, 372)	(77, 215)
WQ1	-$ 14.25	$ 54.65	$ 5.90	$ 22.30	- $ 16.91	$ 42.67	- $ 35.96	$ 29.38
	(-64, 35)	(-2, 111)	(-39, 51)	(-8, 53)	(-20, -15)	(33, 52)	(-51, -29)	(24, 35)
WQ2	$ 46.89	$ 54.12	$ 30.18	$ 39.79	$ 33.92	$ 47.06	- $ 0.51	$ 51.83
	(-10, 104)	(-5, 114)	(-18, 79)	(6, 74)	(26, 40)	(37, 60)	(-1, 0)	(36, 73)
WQ3	$ 42.15	-$ 12.03	$ 11.42	$ 2.84	$ 43.04	- $ 1.91	$ 52.79	- $ 7.13
	(-12, 97)	(-60, 36)	(-35, 57)	(-26, 32)	(26, 56)	(-2, -2)	(35, 73)	(-8, -6)
CHA	$ 213.98	$ 178.17	$ 130.51	$ 126.74	$ 200.34	$ 176.40	$ 145.53	$ 128.52
	(70, 358)	(53, 303)	(37, 224)	(67, 187)	(100, 280)	(106, 252)	(64, 182)	(75, 158)
BIR	$ 176.02	$ 116.54	$ 136.13	$ 123.72	$ 164.33	$ 111.64	$ 137.91	$ 126.87
	(68, 284)	(38, 195)	(53, 219)	(73, 175)	(69, 232)	(68, 154)	(81, 200)	(58, 183)
FISHMUS	$ 138.55	$ 151.65	$ 122.49	$ 98.60	$ 135.28	$ 145.54	$ 120.16	$ 99.24
	(40, 237)	(49, 254)	(39, 206)	(51, 146)	(58, 197)	(59, 223)	(76, 160)	(63, 141)

[5] The delta method and the Krinsky and Robb simulation resulted in almost identical confidence intervals in the Rotoiti case study (Kerr, 2008 pers comm).

[6] As an example calculation, the first conditional parameter mean for HYD in Rotoroa is 0.0284 divided by the negative of fixed price parameter -0.0136 then multiplied by 100 (i.e. normalised) results in $208.72.

Figure 4a: Willingness to pay frequency distribution RPL1 – Rotoroa, Hamilton, Morrinsville and Wellington

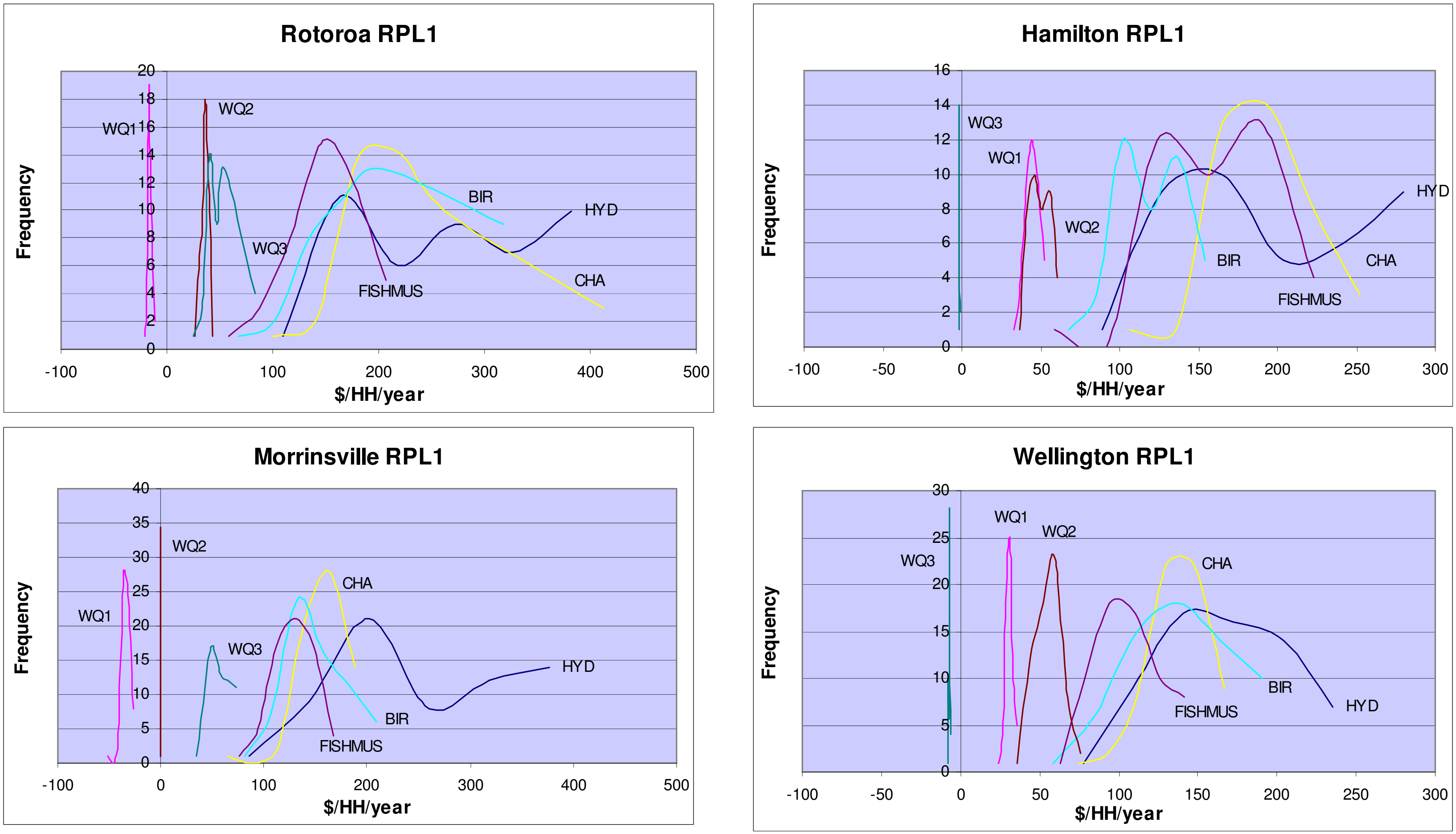


Figure 4b: Willingness to pay frequency distribution MNL – Rotoroa, Hamilton, Morrinsville and Wellington

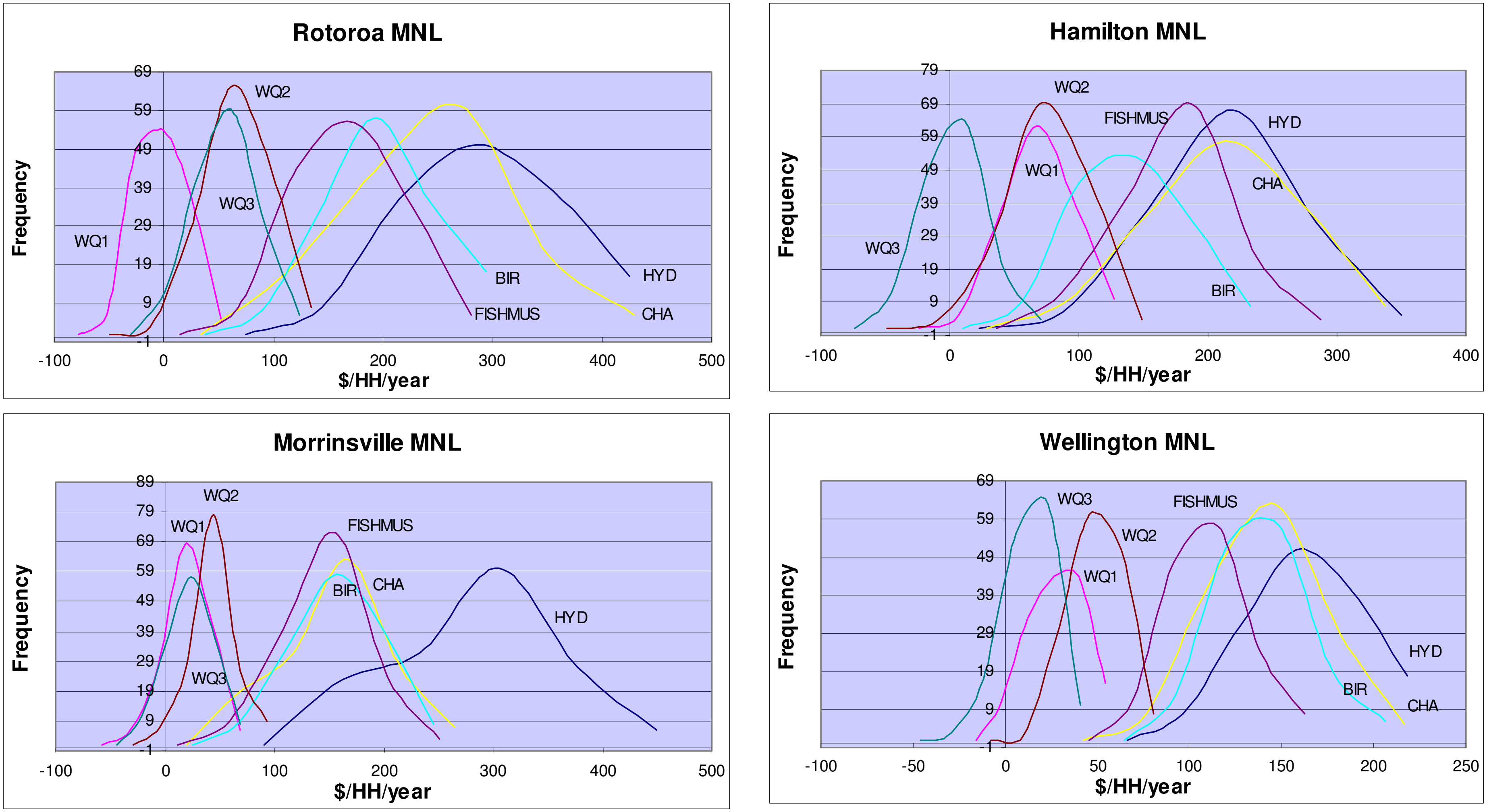


Figure 5a and 5b compare the WTP confidence interval of Lake Rotoroa attributes among the various samples based on RPL1 (95% confidence interval) and MNL (95% confidence interval). The hydrilla attribute generally have a longer confidence interval than the other attributes. Wellington also has a narrower interval compared with the Waikato region samples.

Figure 5a: Willingness to pay confidence interval – RPL1 by location

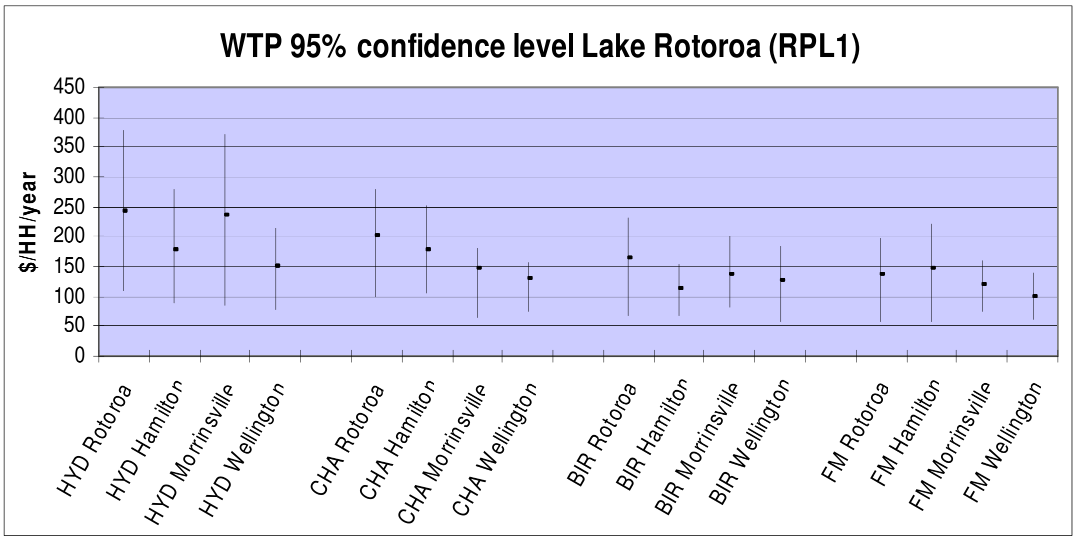
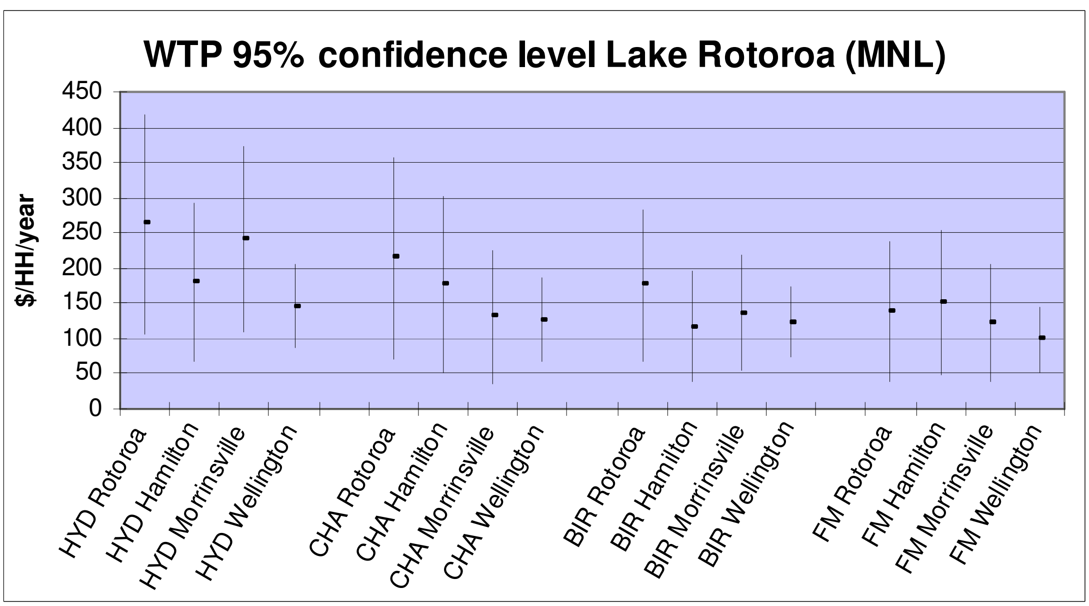


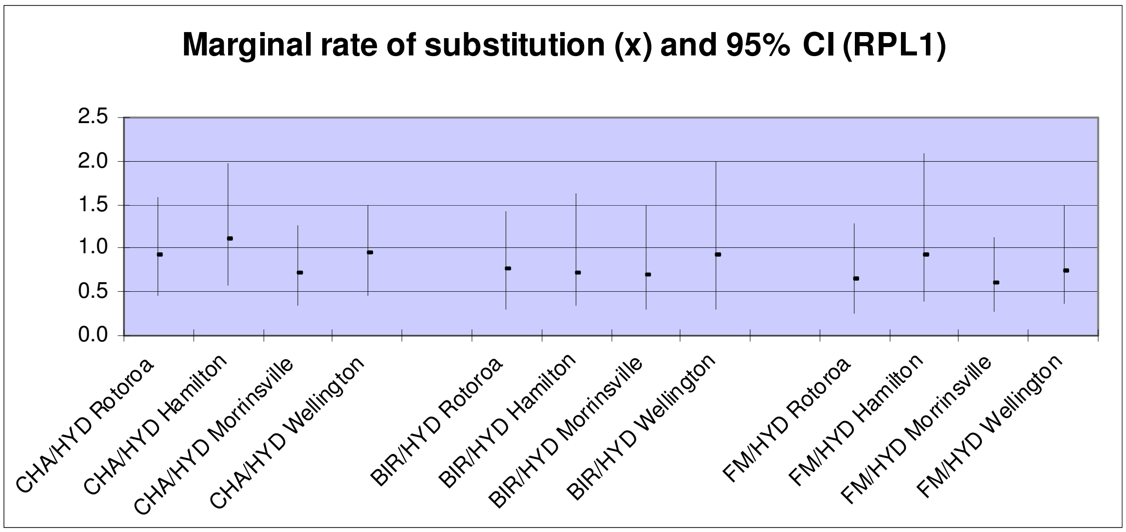
Figure 5b: Willingness to pay confidence interval – MNL by location



8.3.1 Marginal rate of substitution

The marginal rate of substitution (MRS) shows the relative value of one attribute to a reference attribute. The avoidance of hydrilla, which is generally the highest valued attribute, is used as the reference. The mean MRS for Rotoroa, Hamilton, Morrinsville and Wellington and the 95% confidence interval are shown in Figure 6. While the chart shows that the mean MRS is generally below 1x, the upper limit of the confidence interval generally exceeds 1x.

Figure 6: Marginal rate of substitution and confidence interval – by location



8.3.2 Statistical difference for WTP and MRS

The confidence intervals for WTP and MRS by sample and by attribute show some overlaps (see Figures 5 and 6). To assess the statistical significance of differences in WTP and MRS, the equality of the estimates is tested using the asymptotically normal test statistic (Campbell, Hutchinson and Scarpa, 2008):

$$ANTS = \frac{WTP_k^{L1} - WTP_k^{L2}}{\sqrt{Var(WTP_k^{L1}) - Var(WTP_k^{L2})}}$$

where k is the attribute of interest, L1 and L2 are the two locations to be compared and WTP is the WTP or MRS mean.

The results of these tests are shown in Table 8.

Willingness to Pay

In terms of WTP for the attributes, each pair of locations is not statistically different at the 95% confidence level (see Table 8a). By attribute, the WTP are also not statistically different across the four locations. This implies that the WTP for any particular attribute is similar across locations (e.g. near or distant from the lake).

Table 8a: ANTS Tests for equality of WTP

	Rotoroa vs. Hamilton	Rotoroa vs. M'sville	Hamilton vs. M'sville	Rotoroa vs. W'ngton	Hamilton vs. W'ngton	M'sville vs. W'ngton
HYD	1.10	0.60	0.55	1.26	0.64	1.16
CHA	0.85	1.48	1.29	1.86	1.83	1.59
BIR	1.56	0.96	0.72	1.53	0.40	-0.26
FISHMUS	0.20	0.51	0.85	1.23	1.56	-0.76

Note: ANTS of less than 1.96 is not statistically different.

MRS

Comparing each pair of locations the MRS for the attributes are not statistically different at the 95% confidence level (Table 8b). Similarly, by attribute the MRS are also not statistically different. This implies that the relationships between attributes are stable across locations and between attributes within a location.

Table 8b: ANTS Tests for equality of MRS

	Rotoroa vs. Hamilton	Rotoroa vs. M'sville	Hamilton vs. M'sville	Rotoroa vs. W'ngton	Hamilton vs. W'ngton	M'sville vs. W'ngton
CHA/HYD	0.31	0.81	1.33	-0.06	0.76	0.54
BIR/HYD	0.45	0.77	-0.07	0.31	0.43	0.49
FM/HYD	0.53	0.26	-0.69	-0.87	-0.36	0.37

Note: ANTS of less than 1.96 is not statistically different.

8.3.3 Aggregate value

The mean WTP for the environmental attributes have been aggregated to the 2006 census household population of Rotoroa (area near the lake), Hamilton (city population excluding Rotoroa), Waikato (regional population excluding Hamilton), and New Zealand (New Zealand excluding Waikato). This is the Compensating Surplus (CS) illustrated in the equation below:

$$CS = 1/\beta_{PRICE} (\beta_{HYD} * \Delta HYD + \beta_{CHAR} * \Delta CHAR + \beta_{BIR} * \Delta BIR + \beta_{FISHMUS} * \Delta FISHMUS)$$

where conditional parameter means ($\beta_{attribute}$) is a summation for each sample and Δ represent total success in removing hydrilla (HYD) and preserving current levels of charophytes cover (CHA) and species of birds (BIR) and fish/mussels (FISHMUS).

The Net Present Value for 5 years for Compensating Surplus is calculated at $348 million for the Waikato region and $3 billion for New Zealand (aggregating relevant columns in Table 9a). These values have been estimated using a discount rate of 8%.

These estimates of CS are based on estimates of community WTP to have a hydrilla free lake with current levels of charophytes, birds, fish and mussels. CS is a conservative estimate of the value of the lake's natural environment as encapsulated by the four attributes because there is a portion of utility that is unexplained, although in this case the high level of explained utility gives confidence in the results.

Table 9a: Annual and net present value of WTP

Annual value				
(NZ$m)	**Rotoroa**	**Hamilton**	**Waikato**	**New Zealand**
RPL1				
HYD	0.4	7.9	21.7	198.8
CHA	0.3	7.8	13.5	169.1
BIR	0.2	4.9	12.8	166.9
FISHMUS	0.2	6.4	11.1	130.6
Compensating surplus	1.1	27.1	59.0	665.4
Present value for 5 years				
CS @ 8% discount rate	4.4	108.2	235.7	2,656.8
CS @ 6% discount rate	4.6	114.1	248.7	2,803.0

Notes:
1. Hamilton is Hamilton households less Rotoroa households (i.e. rest of Hamilton)
2. Waikato is Waikato households less Hamilton households (i.e. rest of Waikato)
3. New Zealand is New Zealand households less Waikato households (i.e. rest of New Zealand)

Aggregation bias is caused by three main factors (Morrison, 2000): response rate, similarity of preferences of respondents and non-respondents, and correlation between preferences and socio-demographic characteristics (SDCs). The higher the response rate the lower the bias. If non-respondents are randomly distributed, a simple extrapolation of the mean is valid, which is more likely with use values than non-use values, particularly for special interest groups. The lower the correlation between preferences and SDCs, the lesser the adjustment methods will be effective.

As non-response is not applicable to our survey method, we investigated the correlation between preferences and SDCs, specifically income (i.e. high income and low income) and membership in conservation groups. Interaction variables of each SDC with the various attributes showed no significant effect on preferences except for income and price attribute in Wellington and membership in conservation group and price in Wellington, Morrinsville and Hamilton.

Despite the lack of significant effect, Table 9b and 9c show adjustments for income and membership in conservation group. There are two ways of dealing with aggregation bias in random surveys (Morrison, 2000). Firstly, to adjust mean values and secondly to make assumptions about non-respondents. The two approaches are mutually exclusive. Methods for adjusting the mean values include adjusting the sample mean, using weighted regression analysis, and the weighted average approach.

Table 9b shows the mean household income between the sample and the population in each location. As the mean household income is higher in the sample, mean WTPs were adjusted by factors ranging from 0.72 to 0.85. The impact is a 28% reduction in the NPV for New Zealand.

Table 9b: Annual and net present value of WTP (adjusted for income)

Annual value - Adjusted for household income

(NZ$m)	Rotoroa	Hamilton	Waikato	New Zealand
RPL1				
HYD	0.3	5.9	15.5	142.3
CHA	0.3	5.8	9.7	121.1
BIR	0.2	3.7	9.1	119.5
FISHMUS	0.2	4.8	8.0	93.5
Compensating surplus	0.9	20.1	42.3	476.3
Present value for 5 years				
CS @ 8% discount rate	3.7	80.1	168.8	1,901.8
CS @ 6% discount rate	3.9	84.5	178.1	2,006.4

Notes:
1. Hamilton is Hamilton households less Rotoroa households (i.e. rest of Hamilton)
2. Waikato is Waikato households less Hamilton households (i.e. rest of Waikato)
3. New Zealand is New Zealand households less Waikato households (i.e. rest of New Zealand)

Mean household income

(NZ$)	Rotoroa	Hamilton	Morrinsville	Wellington
Sample	$ 73,068	$ 77,250	$ 77,154	$ 79,141
Population	$ 61,767	$ 57,184	$ 55,248	$ 56,651
Adjustment	0.85	0.74	0.72	0.72

Note: Population mean based on Statistics New Zealand 2006 census household income for Hamilton, Waikato and New Zealand.

Table 9c illustrates the adjustment for membership in a conservation group. The samples' ratio of membership in conservation groups is compared with the ratio reported by the Department of Conservation in its national survey (DOC, 2008). As the ratio of membership is generally higher in the sample, mean WTPs were adjusted by factors ranging from 0.39 to 1.13. The impact is a 41% reduction in the NPV for New Zealand.

Table 9c: Annual and net present value of WTP (adjusted for membership in conservation group)

Annual value - Adjusted for conservation group membership

(NZ$m)	Rotoroa	Hamilton	Waikato	New Zealand
RPL1				
HYD	0.1	8.9	13.9	111.8
CHA	0.1	8.8	8.7	95.1
BIR	0.1	5.6	8.2	93.9
FISHMUS	0.1	7.2	7.2	73.5
Compensating surplus	0.4	30.5	37.9	374.3
Present value for 5 years				
CS @ 8% discount rate	1.7	121.7	151.5	1,494.4
CS @ 6% discount rate	1.8	128.4	159.9	1,576.7

Notes:
1. Hamilton is Hamilton households less Rotoroa households (i.e. rest of Hamilton)
2. Waikato is Waikato households less Hamilton households (i.e. rest of Waikato)
3. New Zealand is New Zealand households less Waikato households (i.e. rest of New Zealand)

Membership in conservation group

	Rotoroa	Hamilton	Morrinsville	Wellington	New Zealand
Sample	23%	8%	14%	16%	
Population					9%
Adjustment	0.39	1.13	0.64	0.56	

Note: Population based on Depatment of Conservation survey of people involved in conservation outside the home (DOC Annual Report 2008)

The uncertainty in the mean WTP estimates can be incorporated in the NPV analysis using the risk simulation technique QuRA™[7]. Combining estimates to determine the overall uncertainty need to account for the relationships between the uncertain estimates (i.e. correlation). The environmental attributes exhibit a moderate degree of positive correlation with correlation coefficients ranging from 0.6 to 0.7. Using @RISK, the Excel add-in, the probability distribution of the NPV has been estimated by incorporating the means, standard deviations and correlation coefficients between the uncertain WTP variables in the cashflow and simulated over 5,000 iterations. The expected NPV results for the four locations are shown in Table 9d. A sample NPV distribution is also shown for Rotoroa

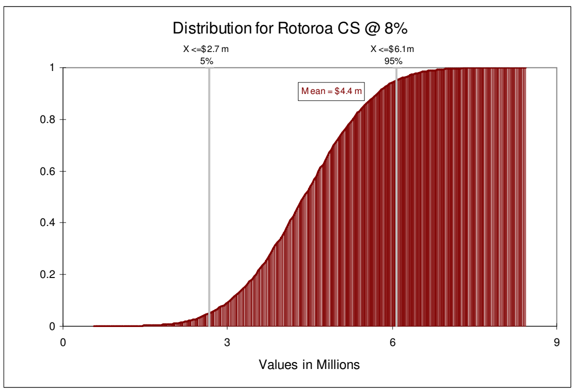
[7] Nimmo-Bell has developed a standard approach to risk simulation called QuRA™ (Quantitative Risk Analysis), which utilises the Excel add-in @RISK to generate distributions of key risky variables and incorporate these into a distribution of the NPV of the project.

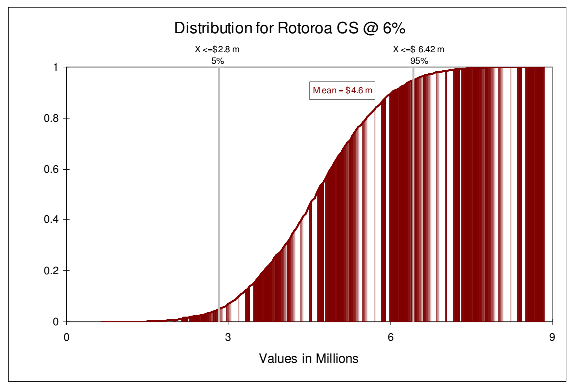
with an expected NPV of $4.4 million (8% discount rate) and a 90% chance that the NPV is between $2.7 million and $6.1 million.

Table 9d: Expected net present value of WTP (with risk simulation)

Compensating surplus - Expected NPV 5 years

(NZ$m)	Rotoroa	Hamilton	Waikato	New Zealand
CS @ 8% discount rate	4.4	108.1	236.1	2,659.2
CS @ 6% discount rate	4.6	114.2	248.3	2,804.1





9 Discussion

Our aim was to elicit quantitative estimates of key environmental values of a freshwater system that could be used for benefit transfer primarily under a situation of extreme time pressure such as in the early days of a pest response. In these situations CBA must be carried out in a minimal time (one to two weeks) so that decision makers have timely information of the most economically efficient response option. Response effectiveness is very time dependent.

The experiment was set up in conjunction with Biosecurity New Zealand to ensure the freshwater system and the impacts of the hypothetical pest studied would have wide applicability to other freshwater systems in New Zealand. Lake Rotoroa scored highly on features that would increase applicability: easily accessible and therefore vulnerable to both pest incursion and the spreading of the pest to other water systems, a range of environmental attributes at risk with both active and passive values, a range of human activities undertaken both on and around the lake. The weed hydrilla was chosen as it is New Zealand's top priority weed. While it is currently restricted to only three locations in Hawkes Bay it has the greatest potential for negative impacts on New Zealand's freshwater systems.

Setting up the experimental design involved four steps. Firstly, discussions with freshwater ecologists and biosecurity specialists captured scientific knowledge about the environment and the pest. Secondly, this information was tested with focus groups to obtain community views on what is important to them about the lake environment and the ranges of the key attributes, including the cost to their household for different levels of the environment. Thirdly, a basic design was formulated based on the scientific and focus group information and this was tested with a convenience sample. Finally, the priors (coefficients for each environmental and price attribute) from the test sample were incorporated into a Bayesian design to maximise efficiency for WTP estimation. The result was a questionnaire that had 12 choice questions for each respondent blocked into five different groups randomly allocated to respondents.

The design, which was subsequently evaluated using Ngene (ChoiceMetrics, 2009), required a minimum sample size that was less than 10% of the actual sample size of 50 respondents per sample. This gave us confidence that the experimental design was suitable even for the relatively small sample size used. As we are interested in extrapolating from the case study we surveyed 4 groups at increasing distance from the lake: by the lake (Rotoroa), opposite side of the city (Rototuna), within the region (Morrinsville) and a remote urban setting (Wellington).

The results were obtained for a simple MNL model before testing the more sophisticated RPL models with varying assumptions on distributions. We found that using a normal distribution to describe environmental attributes produced illogical results (negative WTP in some cases due to fat tails). A truncated triangular distribution, where the standard deviation is limited to the mean value, was used to overcome this problem. The RPL panel model is superior to MNL as it allows for each respondent to have different views while retaining consistency for each respondent. The preferred RPL1 model (environmental attributes truncated triangular distributions and price fixed) had an excellent model fit for all locations equivalent to a linear R^2 of 70-80% and all attributes, except water quality, statistically significant at the 99% level of confidence. Water quality proved somewhat troublesome with lower levels of statistical significance due to the different interpretations people could place on the levels provided (significantly worse, moderately worse and slightly worse and no change).

There was a general high degree of consistency in the ranking on WTP for different attributes within each location. While there appears to be a decline in WTP from close to the lake to more distant locations, tests for the confidence interval at 95% confidence level show that there is no statistical difference among locations for the environmental attributes. This may be explained by heterogeneity of preferences within each sample causing overlapping WTP confidence intervals.

Overall people were willing to pay more to avoid hydrilla infestation than to protect individual existing attributes of the environment. This is in line with the expected large negative impact of the weed and the likelihood that once in the lake there would be a high probability of it spreading to other waterways. Of the existing environmental attributes charophytes, which are of international significance and at high risk from hydrilla, rated highest followed by birds and fish and freshwater mussels.

Pooling tests to indicate significant difference between the different locations were inconclusive. The first test which tested whether there was a preference for the level of one attribute (environmental) being dependent on another variable (location) showed there was no significant difference for the Waikato region sub-samples, but Wellington was significantly different. The second test looked at the error variance between alternatives and found that there was a significant difference at the 99% level and it was due to the unobserved error.

These classical statistical tests rely on a null hypothesis that there is no significant difference between samples i.e. they are the same. This does not necessarily provide meaningful information in the policy context where it is more likely a decision maker is interested in whether they are different. A recent equivalence test where the size of the error is compared with what is acceptable to a decision maker seems more relevant (Kristofersson and Navrud, 2005). The simple version of this test shows that the greater the variance of the difference between two values the less likely one can reject the null hypothesis that the values are different. Use of this test requires an estimate of the acceptable level of transfer error to the decision maker. In the context of pharmaceutical research the standard interval in which values are regarded as equivalent is 20%. For environmental values an error level within 20-40% is likely to be considered equivalent to decision makers for CBA purposes (Navrud and Ready, 2007). We have not undertaken such tests in this project, but this aspect will be addressed in a subsequent phase of the project.

Morrison (2000, p216) notes that distance-decay effect may not exist in all cases and may be more relevant for use values rather than non-use values and it may be that many factors apart from distance may affect WTP, such as environmental preferences in general. In another study investigating distance effects on environmental values, there is no strong decreasing utility with distance and that the distance effect is variable depending on the type of attribute (Concu, 2007). As this study focused on biodiversity, the lack of distance-decay effect is consistent with existence value behaviour where the location of species to be preserved, whether near or far, is not strongly relevant. On the other hand, the value on the eradication of hydrilla is due to the threat that it can easily spread across distances.

Aggregating the mean WTP for the environmental attributes to the 2006 census household population resulted in a Net Present Value for 5 years for Compensating Surplus (CS) for all environmental attributes of $348 million for the Waikato region and $3 billion for New Zealand. These values have been estimated using a discount rate of 8%. Analysis of aggregation bias using interaction variables of income and membership in conservation group SDCs with the various attributes showed no significant effect on preferences.

Despite the lack of a statistical distance-decay effect, on-going work on aggregation issues may suggest a lower value for compensating surplus possibly due to such factors as non-attendance (where respondents may ignore a particular attribute such as cost in stating their preferences). Thus, aggregation based on mean WTPs needs to be treated with caution. There is also the issue of mental account, which is the point that people would not be willing to pay for every lake in New Zealand at the same amount as one lake. This casts doubts on the sense of aggregating values beyond the local or district level (Marsh, pers. comm., 2009). On the other hand biosecurity issues represent a special case. It may be that respondents outside the region are thinking that stopping the spread of a pest at the local level means that it will not spread to their region. This may explain their willingness to pay amounts similar to those at the local level. Decision makers need to apply judgement and common sense to such estimates and depending on the situation restrict aggregation of values to the appropriate level, be that local, district, region or national.

Including the impact of adjustments for aggregation bias for income and membership in conservation group resulted in a reduction of 28% and 41% in NPV respectively.

Incorporating uncertainty in the mean WTP estimates resulted in a 90% probability that the NPV for Rotoroa (local level) would be between $2.7m and $6.1m. Similar levels of uncertainty exist for the other results. The additional information that incorporating uncertainty into the analysis provides is that decision makers become aware of the uncertainty embodied in estimates and they can relate the extent of that uncertainty to the mean values.

10 Conclusions

The choice experiment to estimate environmental values for a freshwater lake has provided statistically significant WTP values that could be used in a CBA. By sampling communities at varying distances from the lake we have been able to show that WTP declines the further one is away from the environmental asset in question, however, this is not statistically significant at the 5% level. This is in line with intuition and gives credence to the aggregated values.

Choice modelling, benefit transfer and risk simulation provide a way of incorporating biodiversity values into CBA that is quick and relatively simple. Concerns about bias particularly in aggregating WTP values can be reduced by making adjustments to transferred values and by decision makers applying judgement and common sense to the level of aggregation that is relevant.

The results are presented as distributions of WTP which gives analysts and decision makers an improved understanding of the uncertainty embodied in the estimates. This uncertainty can be placed alongside the uncertainty inherent in the estimates of physical damage from a pest incursion when constructing and reporting on the costs and benefits of different response options.

By extending quantitative CBA beyond economic impacts to include impacts on environmental values, decision makers are likely to make better decisions on resource allocation.

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